Eurasia Journal of Science and Technology
ISSN: 2663-1016
DOI: 10.61784/ejstv6n293

DESIGN OF A DISPOSABLE WOODEN TABLEWARE PACKAGING INSPECTION DEVICE

JianWu Hou, TianYue Jiang*, JiBo Li, HaoJun Zhao
College of Information and Electronic Technology, Jiamusi University, Jiamusi 154007, China
Corresponding Author: TianYue Jiang, Email: 13704503245@163.com

Abstract: This paper addresses the shortcomings of traditional manual sorting methods in the field of packaged tableware by proposing a novel disposable wooden tableware packaging inspection mechanism. Through analysis and comparison of existing technologies, a design scheme was determined, and the structural design and working principles were elaborately described. This mechanism utilizes the principle of buoyancy to stratify water and employs devices such as drive motors and rotating screws to achieve batch inspection of packaged tableware. Its advantages include scientifically reasonable structural design, safe and convenient operation, and efficient separation of intact and damaged wooden tableware, thereby enhancing inspection efficiency. This mechanism provides a solution for packaging quality inspection, with the potential to play a significant role in reducing pollution, minimizing resource wastage, enhancing product quality, and maintaining brand image. It is expected to make a positive contribution to the industry's development.
Keywords: Disposable wooden tableware; Packaging inspection mechanism; Structural design; Working principle

1 INTRODUCTION

In recent years, with the continuous implementation of "plastic-restriction" policies worldwide[1], traditional disposable plastic tableware is gradually being replaced by disposable wooden tableware, which is favored by more and more consumers as an environmentally friendly and healthy choice[2]. However, improper packaging during the production process may lead to the rupture and leakage of packaging bags, exposing wooden tableware to the air and causing secondary pollution by breeding a large number of bacteria. This not only potentially threatens the health of consumers but also affects the reputation of companies. Therefore, quality inspection of packaged tableware to remove defective items contributes to improving the overall quality of batched products and ensures the personal health and safety of users. Currently, to prevent damaged packaged tableware from entering the market, manufacturers mainly rely on visual inspection by human eyes for quality sorting, requiring substantial number of workers to manually select them one by one beside the conveyor belt of the tableware production line. However, this manual inspection method suffers from low efficiency, high costs, and the possibility of human error leading to misjudgments and omissions[3], resulting in some damaged packaged tableware still potentially entering the market and affecting product quality and corporate image. To address these issues, this paper aims to design a disposable wooden tableware packaging inspection mechanism (referred to as the packaging inspection mechanism hereafter) to enhance the controllability and accuracy of packaging quality inspection, ensuring that product quality meets standards. This is intended to meet consumer demand for health and safety while enhancing the competitiveness and sustainable development capabilities of enterprises in the market[4].

2 MECHANICAL STRUCTURE DESIGN

As illustrated in Figures 1 to 5, the packaging inspection mechanism features the following enhanced mechanical structural design:
(1) Parallel tracks are installed on the top sides of the mounting plate, with mobile seats mounted on the top of the tracks. Electric wheels are installed at the bottom of the mobile seats, engaging with the tracks to ensure stable movement of the mechanism during operation. By engaging the electric wheels with the tracks, the power of the electric wheels is effectively transmitted to the entire mechanism, enabling it to move steadily along the track trajectory. This design ensures stable speed and trajectory of the mechanism during the inspection of packaged tableware.
(2) The top center of the mobile seat is equipped with a lifting cylinder, and a mounting platform is installed on the top of the lifting cylinder. One side of the mounting platform is fitted with a supporting sliding rod, while the top is installed with a drive motor. The input end of the drive motor is electrically connected to the external power output end, and its output end is connected to one end of the rotating screw. The purpose of the drive motor is to control the movement of the mechanism, allowing it to operate according to the designed program and path, thereby achieving automated detection of the packaged tableware.
(3) The outer side of the supporting sliding rod is fitted with an extendable sleeve rod, inside of which a groove is provided for supporting the sliding rod's movement. The supporting sliding rod is located inside the groove, with both its outer surface and the inner wall of the groove being smooth to reduce relative friction between them, facilitating smoother movement of the extendable sleeve rod on the supporting sliding rod. This helps control the position of the

filtering hole plate, achieving effective stratification and separation of the packaged tableware. The top of the extendable sleeve rod is connected to the rotating screw, so when the drive motor starts and rotates the rotating screw, the threaded connection between the rotating screw and the screw seat causes the extendable sleeve rod to move on the supporting sliding rod. The extendable sleeve rod then extends or retracts according to the movement of the rotating screw, allowing the filtering hole plate to move up and down in the water tank. With the assistance of the extendable sleeve rod, the position of the filtering hole plate can be accurately controlled.

(4) At one end of the extendable sleeve rod's top, a screw seat is welded, and the other end of the rotating screw is connected to the screw seat through threads. The screw seat serves as a fixed support for the rotating screw, supporting and maintaining the stable position of the rotating screw. The threaded connection between the rotating screw and the screw seat enables the rotating screw to maintain a stable axis of rotation during operation, ensuring the accuracy of the movement and positioning of the extendable sleeve rod. The rational design of the screw seat directly affects the stability and efficiency of the entire mechanism.

(5) At the bottom of the extendable sleeve rod, an electric cylinder is installed, with its input end electrically connected to the external power output end. The electric cylinder controls and adjusts the position of the moving parts. At the top end bottom of the extendable sleeve rod, a first rotating seat is welded, which connects the connecting rod and the filtering hole plate, and tilts the filtering hole plate when necessary. The bottom of the first rotating seat is rotatably connected to the connecting rod, which serves to connect the first rotating seat and the second rotating seat. The connecting rod is located at the bottom of the first rotating seat, connected to the first rotating seat by welding, and extends to the second rotating seat. When the extending end of the electric cylinder retracts, the connecting rod rotates together with the first rotating seat, causing the first rotating seat to tilt, thereby tilting the filtering hole plate. This action discharges the damaged utensils into the discharge pipe and sends them to the collection box. Therefore, the connecting rod plays a crucial role in connecting and transmitting motion in the packaging detection mechanism, ensuring the accurate movement of the filtering hole plate and effectively handling the packaged tableware.

(6) The outer side of the connecting rod is welded with the second rotating seat, which is rotationally connected to the extending end of the electric cylinder. The second rotating seat serves as the rotational pivot of the other end of the connecting rod, and it is rotationally connected to the extending end of the electric cylinder. When the extending end of the electric cylinder retracts, the second rotating seat rotates accordingly, transmitting the tilting action to the first rotating seat and the filtering hole plate through the connecting rod. This function enables the discharge of damaged packaged tableware from the discharge pipe and their collection in the collection box. Therefore, the second rotating seat plays a role in rotating and transmitting motion in the packaging detection mechanism, working in conjunction with other components to handle and collect packaged tableware.

(7) At the bottom of the connecting rod, there are connecting ears, which ensure that two filtering hole plates can be tightly fitted together without interference from the ears affecting their fit. The longitudinal cross-section shape of the connecting ear is "L" shaped, which allows the connecting ear not to hinder their fitting when the two filtering hole plates are closely adhered. The design of the connecting ears helps maintain the sealing between the filtering hole plates, ensuring the effective isolation of packaged tableware stratified in water. Therefore, the connecting ears play a role in maintaining the fitting and sealing of the filtering hole plates in the packaging detection mechanism, ensuring the smooth progress of the detection process.

(8) At the bottom of the two connecting ears located on the same track, filtering hole plates are welded, and the function of the filtering hole plates is to isolate and filter the stratified packaged tableware in the water. The packaging detection mechanism utilizes buoyancy to stratify the packaged tableware, with the filtering hole plates playing a crucial role. When the two filtering hole plates come into contact, they separate the stratified packaged tableware in the water, allowing intact utensils to float on the water surface while damaged ones are trapped in the space between the filtering hole plates. Consequently, the filtering hole plates effectively separate intact packaged tableware from damaged ones, facilitating subsequent discharge and collection tasks. Therefore, the filtering hole plates play a critical role in screening and separating packaged tableware in the packaging detection mechanism, ensuring the accuracy and efficiency of the detection process.

(9) Between the installation boards, there are reservoirs, and on the top of both sides of the reservoirs, there are movable grooves. The longitudinal cross-section of the movable groove is equal in size to that of the filtering hole plate. When the filtering hole plate is inside the movable groove, it can seal the movable groove to prevent water from overflowing from the joint. One side of the reservoir bottom is perforated and connected to a discharge pipe, which has a parallelogram-shaped cross-section with a sloping bottom surface to facilitate the discharge of unsuitable packaged tableware. The ends of the discharge pipe are rotated by the spindle, one of which is connected to the output end of the rotating motor, while the input end of the rotating motor is electrically connected to an external power source. One side of the shaft is welded with a sieving hole plate, located at the bottom inside the reservoir. The outer side of the sieving hole plate tightly adheres to the inner wall of the reservoir to prevent utensils from leaking from the connection between the sieving hole plate and the inner side of the reservoir. At the bottom of the discharge pipe, there is a hinged sealing door to prevent water or residual objects from leaking out of the discharge pipe, ensuring a clean and tidy discharge process. One side of the reservoir bottom is perforated and connected to a drainage pipe for draining water from the reservoir.

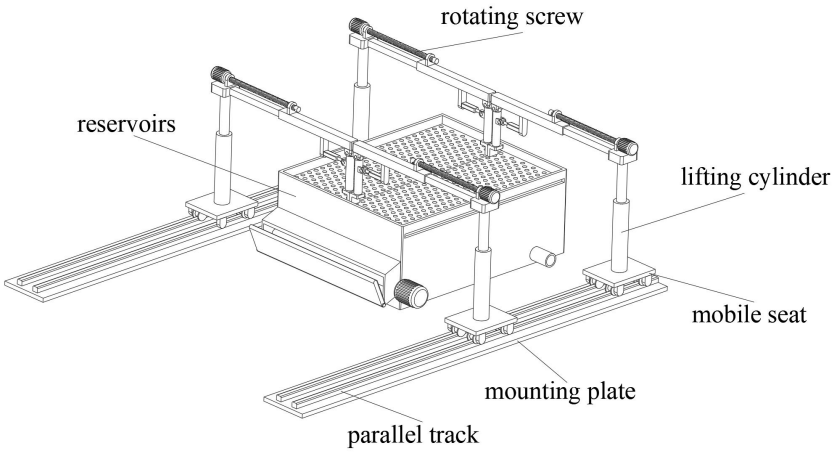

Figure 1. Schematic diagram of the three-dimensional structure

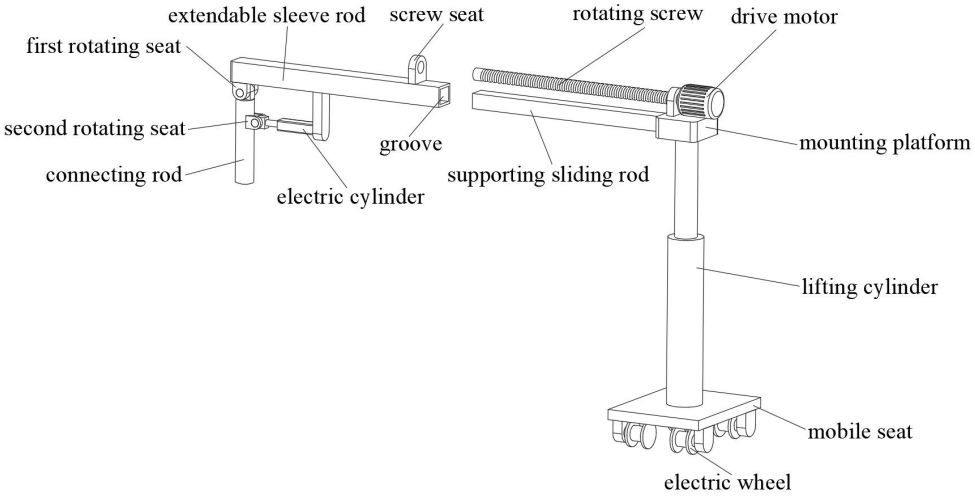

Figure 2. Schematic diagram of the installation structure of the moving seat

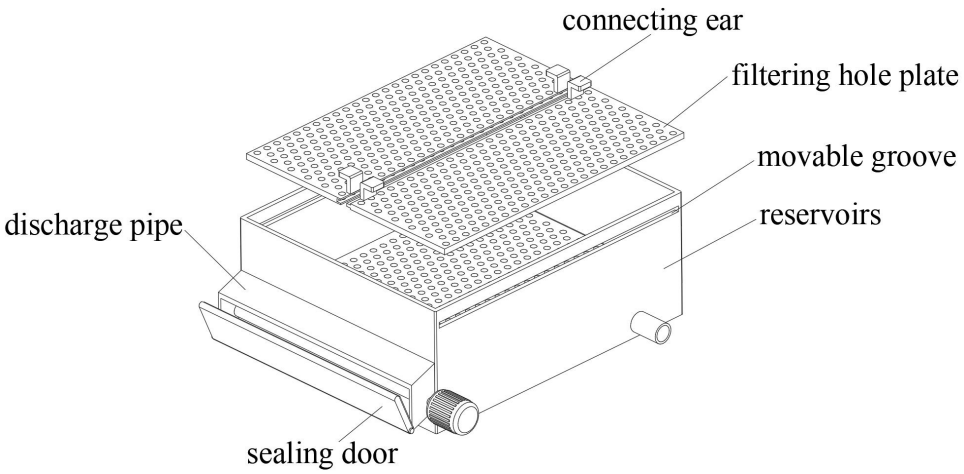

Figure 3. Schematic diagram of the filter plate installation structure

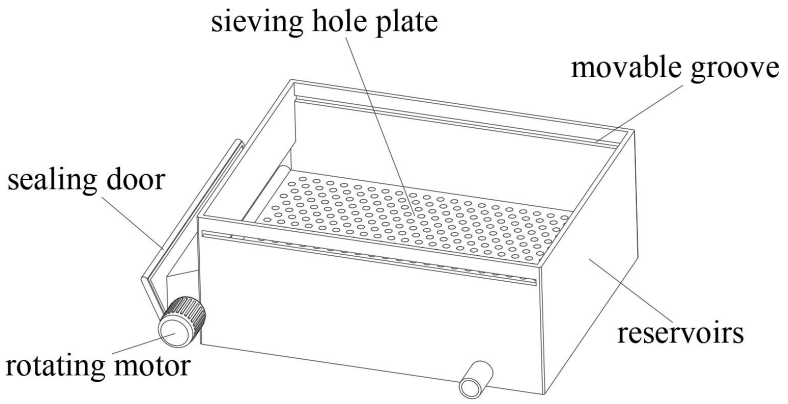

Figure 4. Schematic diagram of the selection hole plate installation structure

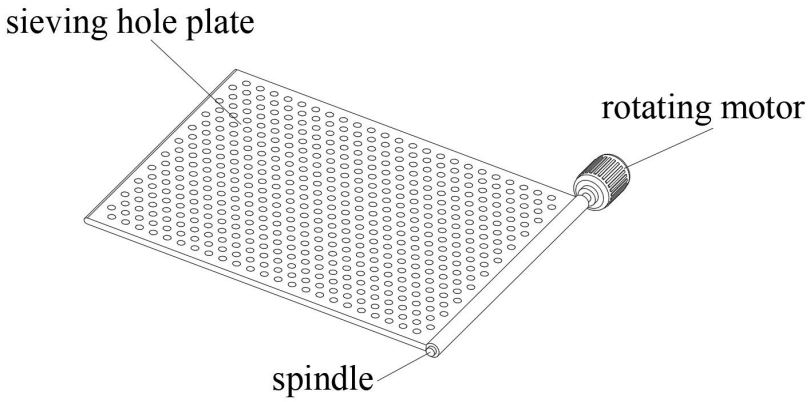

Figure 5. Schematic diagram of the installation structure of the rotating motor

3 DESIGN ADVANTAGES

The packaging detection mechanism presented herein offers significant advantages compared to existing technologies. Its specific strengths are outlined as follows:

3.1 Scientific and Rational Structural Design

This packaging detection mechanism incorporates components such as tracks, movable seats, electric wheels, lifting cylinders, support rods, rotating screws, telescopic rods, electric cylinders, connecting rods, and filtering hole plates. The structural design has been meticulously considered and planned, ensuring functional complementarity and coordination.

3.2 Convenient and Safe Operation

During usage, the operation is convenient, safe, and reliable. With the operation of the driving motor, the rotation of the screw rod, and the isolation of the filtering hole plates for stratifying water, the opening of the drainage pipe and the lifting operation of the lifting cylinder can be easily controlled by the operator, thereby enhancing the convenience and safety of the operation.

3.3 Improved Inspection Efficiency

Batch inspection of packaged utensils is achieved through automated equipment operation[5]. The movement of the filtering hole plates and the arrangement of the collection box enable the rapid collection of damaged packaged utensils, thereby enhancing inspection efficiency.

3.4 Prevention of Damaged Utensils Entering the Market

The efficient operation of the equipment effectively prevents damaged packaged utensils from entering the market, thereby avoiding damage to brand reputation and ensuring a dual safeguard of product quality and consumer interests[6].

3.5 Resource Recycling

The design of components such as the collection box and drainage pipe in this packaging inspection mechanism enables the recycling of damaged utensils, aligning with environmental protection and resource conservation principles[7].
In summary, this packaging inspection mechanism not only demonstrates significant advantages in terms of convenient operation, high safety, and efficiency improvement but also contributes to safeguarding product quality and brand reputation. This underscores its innovation and practicality within existing technology.

4 THE WORKING PRINCIPLE AND OPERATIONAL PROCEDURE

The working principle and operational procedure of this packaging inspection device are described as follows:

4.1 Preparation Stage

Prior to operation, the filtering plates are positioned within the movable slots, with the connecting ears tightly fitted against the inner walls of the water reservoir on both sides. The filtering plates are in a horizontal position. The water reservoir is filled with water using an external water pump, and batches of packaged disposable wooden utensils are poured into the water reservoir.

4.2 Stratification in Water

Intact wooden utensils, buoyed by buoyancy, float on the surface of the water, while damaged ones sink due to water ingress into the packaging, resulting in a stratified configuration within the water.

4.3 Filtration and Separation

The driving motor initiates operation, causing the rotation of the rotating screw. The rotating screw is threaded into the screw seat, and as it rotates, the telescopic rod gradually moves away from the support rod. The filtering plates progressively move towards the center of the water reservoir until they make contact. When the two filtering plates come into contact, the driving motor ceases operation, and the filtering plates isolate the stratified wooden utensils within the water.

4.4 Drainage and Removal

The drainage pipe is opened, allowing a portion of the water in the reservoir to be discharged. This causes intact wooden utensils floating on the water surface to fall onto the surface of the filtering plates. The discharged water can be collected for recycling. The lifting cylinder ascends, detaching the filtering plates from the water reservoir. The electric wheel starts, driving the moving seat to move along the track, removing the filtering plates from the top of the water reservoir.

4.5 Collection and Recycling

After the filtering plates are removed from the top of the water reservoir, a collection box can be placed at the bottom of the filtering plates. Then, the electric cylinder is activated to retract its extending end. With the rotational connection between the first and second rotating seats, the filtering plates tilt, causing the packaged utensils on them to fall into the collection box, completing the collection process. Once collection is finished, the electric cylinder returns the filtering plates to a horizontal position and then to their initial state. External water pumps replenish the water in the water reservoir, awaiting the next batch of packaged utensils for inspection. Repeat these steps to complete the mass inspection of packaged utensils.

4.6 Conclusion Phase

After all batches of packaged utensils have been inspected, open the drainage pipe to discharge all the water from the water reservoir, causing damaged utensils to fall onto the surface of the filtering plates. Open the sealing door, activate the rotary motor, and the rotary motor drives the shaft to rotate. Rotation of the shaft tilts the filtering plates, causing damaged packaged utensils to be discharged from the discharge pipe. Place a collection box at the bottom of the discharge pipe to collect the damaged packaged utensils for further recycling.
Through the above process, this packaging inspection mechanism can effectively conduct rapid and accurate inspections of the packaging of disposable wooden tableware, ensuring that the product quality meets the standard requirements.

5 CONCLUSION

China is the world's largest producer and consumer of takeaway food packaging, with a growing demand for disposable wooden packaging tableware[8]. In response to the issues of low efficiency, high cost, and the inability to meet actual production needs associated with traditional manual sorting methods, this paper proposes a disposable wooden tableware packaging inspection mechanism to address the current pain points in production. The advantages of this inspection mechanism lie in its scientifically reasonable structural design, convenient and safe operation, and effective separation of intact and damaged packaged tableware, thereby enhancing inspection efficiency and ensuring product quality meets standards. Furthermore, against the backdrop of increasingly stringent environmental policies, this mechanism offers multiple advantages such as reducing environmental pollution, improving product quality, and maintaining brand image. However, despite the significant progress made by this mechanism, there is still room for improvement. For example, further optimization of structural design and the introduction of more advanced technologies are needed to meet the growing demands and standards of the market. In summary, this mechanism provides a practical and feasible solution for packaging quality inspection for manufacturers of disposable wooden tableware, with the potential for wide application in actual production. It aims to drive sustainable development within the industry while promoting the protection and sustainable utilization of environmental resources.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

FUNDING

This article was supported by the National General Project: Heilongjiang Province University Students' Innovation and Entrepreneurship Training Program Project, Project Title: IntelliEye Defect Recognition - Visual Inspection System for Surface Imperfections on Disposable Wooden Tableware (Project Number: 202310222068).

REFERENCES

[1] Chen, X., Chen, F., Wang, G., Ma, X., Wang, J., Deng, J. Eco-friendly, disposable bamboo fiber dishware: Static and dynamic mechanical properties and creep behavior. Industrial Crops and Products, 2022, 187, 115305.
[2] Li, L., Li, Z., Han, H., Yang, L., Feng, X., Roli, F., Xia, Z. Wooden spoon crack detection by prior knowledge-enriched deep convolutional network. Engineering Applications of Artificial Intelligence, 2023, 126, 106810.
[3] Golkar, E., Patel, A., Yazdi, L., Prabuwono, A. S. Ceramic tile border defect detection algorithms in automated visual inspection system. Journal of American Science, 2011, 7(6), 542-550.
[4] Safin, R. R., Talipova, G. A., Galyavetdinov, N. R. Design of packaging materials based on polylactide and wood filler. International Journal of Engineering and Technology (UAE), 2018, 7(4.36), 1089-1091.
[5] Judal, A., Bhadania, A. G. Role of machine vision system in food quality and safety evaluation. International Journal of Advance Research and Innovation, 2015, 3(4), 611-615.
[6] Wandel, M., Bugge, A. Environmental concern in consumer evaluation of food quality. Food quality and preference, 1997, 8(1), 19-26.
[7] Chen, X., Zhong, T., Jiang, H., Wang, J., Chen, F., Wang, G. Recyclable cellulose nanofibrils composite film derived from bamboo fiber tableware waste. Industrial Crops and Products, 2023, 205, 117539.
[8] Semple, K. E., Zhou, C., Rojas, O. J., Nkeuwa, W. N., Dai, C. Moulded pulp fibers for disposable food packaging: A state-of-the-art review. Food Packaging and Shelf Life, 2022, 33, 100908.